



Socio-spatial differentiation and residential segregation in the Chinese city based on the 2000 community-level census data: A case study of the inner city of Nanjing



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ABSTRACT

Socio-spatial differentiation and residential segregation have been studied extensively in numerous cities and have contributed significantly to the understanding of urban spatial and social structures. Analyses of diverse data sets at varied spatial scales have supported the development of theoretical frameworks. However, the majority of Chinese case studies published in recent decades were dominantly based on either non-spatial data or population census data at sub-district (or *jiedao* in Chinese) level. These analyses have been limited through using low-resolution aggregate data resulting in incomplete or biased findings. This paper aims to examine the fine-scale socio-spatial structure of the inner city of Nanjing using the fifth population census data of 2000 at the lowest spatial scale – community (or *juweihui* in Chinese) level. Our findings reveal that the policies of the socialist era and the initial outcomes of the introduction of a free market, particularly with regard to the creation of new elite spaces within the inner city, have shaped a complex pattern of socio-spatial differentiation and residential segregation.

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Introduction

Urban spatial structure has long held an interest for those who study cities. It is one of the oldest and most basic lines of urban research, but also one that has been resurgent in recent years. The origin of this resurgence in part is due to the development of highly advanced computational techniques which are now being applied to the analysis of massive, complex and controversial data sets. In part, however, the resurgence also stems from an increasing acceptance on the part of Anglophone geographers of the diversity of urban forms present in Africa, Asia and Latin America, and the increasing importance of these cities to the global urban system (Friedmann, 2010; Johnston, Michael, & James, 2007; Logan, 2013; Massey, 2012; Simone, 2004). China has attracted a substantial amount of this attention, which is unsurprising given the extraordinary growth in Chinese cities and the fundamental shifts in Chinese political economy. Our study is motivated by two sets of concerns. In general, the well-known and dramatic

changes in the Chinese economy since the beginning of free-market reforms in 1978, but especially in the last quarter century, have created one of the most dynamic and rapidly expanding urban systems in the world. The unique combination of an ancient urban form overlain by two dramatically different, but exceptionally powerful, forces in the centrally planned socialist city and the negotiated free-market city provide an exceptional opportunity to understand urban processes in general. In addition, the indications that Chinese cities are moving more toward a western model with high degrees of economic spatial segregation (Yeh, Xu, & Hu, 1995; Wu & Webster, 2010; Zhao, 2013), and in some cases higher degrees of racial and ethnic segregation, is cause for concern (Gu, Wang, & Liu, 2005).

More specifically Nanjing, the capital of Jiangsu Province, provides some contrast with the more commonly studied and much larger trio of Chinese super cities, Shanghai, Beijing and Guangzhou. At the same time it is still a large coastal city with some of the characteristics typically associated with rapidly urbanizing areas.

We address two primary research questions. First, is there an identifiable spatial structure to the inner city of Nanjing, and if so, what are its characteristics? Second, are the known features of the nationalist, socialist and free-market cities identifiable in

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this structure? There is a large and growing literature on the spatial structure of free-market Chinese cities and on the related issue of socio-spatial segregation. However, the study of spatial structure in Chinese cities has faced some significant difficulties. By their nature, these studies are data intensive and require a level of spatial detail that has previously been unavailable in China (Cheng, Turkstra, Peng, Du, & Ho, 2006; Li & Wu, 2008). This study addresses that issue through the use of residential community data from the Chinese census that have been linked to an accurate, spatially rectified map of community areas, which allows us to examine the more detailed spatial structure focusing on the inner city, at a time when it had just begun to experience dramatic changes.

The rest of the paper is organized as follows. Section 'Urban socio-spatial differentiation in the context of China' provides a brief overview of the literature on urban residential segregation and socio-spatial differentiation in the context of China, followed by a justification of the data set and methods selected in Section 'Methodology'. Section 'Results' focuses on interpreting and discussing the results from a series of statistical analyses that shed light on the characteristics of residential segregation and socio-spatial structure in the case of inner-city Nanjing. It is argued in Section 'Discussion' that the inner city area of Nanjing has experienced massive residential segregation caused by the dualistic dynamic structure of housing differentiation resulting from a growth-led urban housing market and persistent institutional bias with regard to housing redistribution at the turn of the 21st century. Section 'Conclusion' ends with general conclusions.

Urban socio-spatial differentiation in the context of China

Segregation refers to a spatial social differentiation which has many dimensions but is most often related to racial and ethnic segmentation, and occasionally class or income segmentation (Logan, 2013; Madrazo & Van Kempen, 2012; Massey, 2012). Although segregation is common across many of the Anglophone countries, it reaches its zenith in the US with African-American segregation (Iceland & Sharp, 2013; Johnston et al., 2007). Black segregation has long been identified in US cities (e.g. Park, Burgess, & McKenzie, 1967) but remains an enduring issue and with a declining trend (Iceland & Sharp, 2013; Logan, 2013). Most European cities exhibit moderate levels of ethnic segregation (Kazepov, 2005) and cities in the UK display moderately high levels of segregation, particularly among South Asian immigrants (Johnston et al., 2007; Peach, 2006) and Muslim religious groups (Gale, 2013).

The case studies mentioned above have stimulated an interesting research question: do Chinese cities exhibit this trend toward socio-spatial segregation? Traditionally, with relatively few significant minority groups in the large coastal cities, the focus has been on other factors such as status (Gu et al., 2005), tenure (Li & Wu, 2008; Tian, Wu, & Yang, 2010), migrant workers (Liu, Dijst, & Geertman, 2014; Shen, 2002), income (Zhao, 2013) and socialist urban policies (Wang, 2003; Wu & Webster, 2010).

In most cases, researchers have noted comparatively small, but increasing levels of segregation, which appears to be substantially different from that in western cities. For example, the segregation of African Americans in the US can be attributed to the overarching cause of racism and economic factors (Massey, 2012). By contrast, the social and spatial differentiation characterizing urban China in the post-reform era results from an imbalance in the distribution of economic returns and social benefits and their spatial consequences during the processes relating to globalization and market-oriented institutional transformations (Wu, 2002). As a part of China's globalization processes, central government relinquished some of the monopolistic sectors or institutions. This

governmental move has caused the polarization of internal income distribution from the 1990s onwards (Gu et al., 2005; Wu & Webster, 2010). What is even worse, is that the subsequent reforms with regard to tax sharing in 1994 and housing distribution in 1995 have encouraged local governments to initiate growth-led neoliberal practices in the housing market. Local governments were incentivized to raise revenue more from housing and land markets during housing privatization than from production or commerce, which directly caused significant residential segregation and consequently socio-spatial differentiation. Madrazo and Van Kempen (2012) outline five general processes or "trends" that typically connect with spatial segregation and identify what they term as "Preferences, Position, Policies, Players and Trends". They suggest that while all these processes are at work in China, policies as an integral factor are perhaps the most crucial in understanding socio-spatial segregation. This is due to the overarching role of the government in regulating housing choices through the traditions of danwei and hukou and more recently through its role as a player in the development process (Li & Wu, 2008; Liu et al., 2014; Yeh et al., 1995). Through institutional transition in some danwei or work units (state-owned enterprises and public sector units), most of their workers turned into commercial enterprise employees and accordingly lost their privileges in the provision of housing, welfare, and the education of their children, while the unreformed danwei and their workers retain their benefits as before.

However, the increasing importance of market forces is creating socio-spatial segregation in part through the operation of the housing market and in part through the strong influence of urban development fueled by free-market based economic growth. This socio-spatial transformation is mostly attributed to the operation of the free market (Wang, 2003; Wu, 2002). However, Zhao (2013) also argues that two of the most relevant institutional factors influencing social segregation in China's cities remain the hukou system and the dual land system.

Consequently, a combination of market factors and the institutional bias toward those still "privileged" in housing distribution turned economic differentiation into residential segregation (Chen, 2012). Importantly, however, the processes are complex and reflect the interaction of powerful forces set in place in the socialist era with the equally powerful market forces (Wang, 2003; Wu & Webster, 2010).

This socio-spatial complexity in Chinese cities in transition has pushed researchers to use a range of data reduction techniques to find interpretable patterns. Gu et al. (2005) identified five basic clusters after conducting a factor analysis on data from Beijing. These clusters focus on inner-city versus suburban locations, density, and income. They also found four sub-clusters again using the same factors with the addition of ethnicity. Their four significant factors: "land use intensity, neighborhood dynamics, socio-economic status and ethnicity" showed some evidence of concentric patterns (based on land use intensity) and sectoral patterns (based on neighborhood dynamics and ethnic clustering). Li, Hou, Chen, and Zhou (2010) detected a general concentric pattern in Guangzhou with the old urban core surrounded by reform housing (socialist era housing sold to the residents at a discounted price) with emerging areas of commodity housing at sub-district level. In Shanghai, Li and Wu (2008) noted the continued importance of work-unit housing in some clusters and tenure-based clustering in commodity housing. They also found that Chinese cities traditionally display five major classes of social areas that are somewhat different from those concluded by Gu et al. (2005). Nevertheless, these data sets used in the three super cities are either limited in sub-district levels (Gu et al., 2005; Li et al., 2010), which is an equivalent of 'town' in Western countries, or include a less-than-sufficient number of variables using

community level data that do not have a spatial boundary (Li & Wu, 2008). We aim to explore if any new findings can be revealed using community level data with an accurate spatial boundary, which is equivalent to the census tract or block level in western studies.

The focus of this paper is different from the above-mentioned case studies as the inner city of Nanjing is chosen as the case study area. As a well-known historic city, Nanjing was a heavy manufacturing center with an emphasis on petrochemical, machinery, and textiles during the socialist era. Unlike other heavy industrial cities, particularly in northeast China, Nanjing has not been severely influenced by industrial restructuring in the 1990s (Wu & He, 2005). However, as in many other Chinese mega-cities, massive urban redevelopment started in Nanjing during the 1990s, following the update of the metropolitan master plan, making the year 2000 an important time point to study China's large cities in transition. In 2000, Nanjing was very much in transition from a socialist manufacturing center to a free market service economy with strong manufacturing and foreign investment, though it lags behind Shanghai, Beijing and Guangzhou. This paper will analyze the changing socio-spatial structure during this transition in an inner city with a long history of urban change.

Methodology

Data and study area

China has conducted six national population census surveys since the 1980s and these form the dominant source of data for analyzing the demographic and social structures of Chinese cities. Not only have more census items been added in the latest survey (e.g. census surveys of 2000 and 2010) but also spatial and temporal scales have been largely improved and are of much better quality than before. The administrative system in mainland China is a 7-tier hierarchy (see Fig. 1), in which district, sub-district (*jiaodao* in Chinese) and community (administered by residential committee) are the dominant spatial statistical units for releasing population census data in China, and can be equivalent to the units of local authority, ward and super output area—lower layers in the UK respectively in terms of area. However, the official release of census data is most often only made at the levels of district and sub-district by National Bureau of Statistics (e.g. censuses 2000

and 2010) and the census data at community level is only available un-officially from local organizations. The main barrier to the analysis of socio-spatial structure is the lack of spatial data showing community boundaries. China's population growth has reconfigured the administrative size of the community level and the rapid urban growth stimulated by unprecedented urbanization has resulted in changes in the boundaries of communities (Cheng et al., 2006). Consequently, the use of census data at community level may reveal different socio-spatial structures from the studies based on district and sub-district units (e.g. Li et al., 2010; Yeh et al., 1995).

In this paper, a total area of 43-square-kilometer in the inner city of Nanjing was selected as a case study, which covers 29 sub-districts or *jiedao*, and 244 communities (Fig. 2). This study area has a total population of 1,358,714 amounting to 54.2% of Nanjing's urban residents in 2000, representing the core of Nanjing's built environment.

Analysis methods

Since Shevky and Bell (1955) proposed the famous three dimensions of segregation—socioeconomic status, ethnicity and life-style—in their studies of Western cities, similar approaches have been successfully used in non-Western urban circumstances (Johnston et al., 2007; Li et al., 2010). As socio-economic differentiation is the principal determinant of residential segregation in Chinese cities (Wu & Webster, 2010), the following three categories of variables that are similar to those used for the case study of Guangzhou (Li et al., 2010) are chosen for this case study: (1) the common feature of demography; (2) occupational characteristics; and (3) housing. As Nanjing is regarded as the third largest center for higher education and research in China, only after Beijing and Shanghai, in this paper a new occupational structure is added to the analysis, which differs from that of Li et al. (2010). In total, 36 census variables are utilized to capture the above-mentioned three dimensions and a matrix is constructed for the 244 communities. Given that a large number of variables make any worthwhile judgment and interpretation impossible, the method of Quartimax rotation in Primary Component Analysis (PCA) that yields the most interpretable results was applied to the matrix. When running the PCA tool, a hierarchical clustering function based on Euclidean distances was chosen to identify the socio-spatial linkages between communities across the inner city. Then the main characteristics of each cluster are estimated using the sum of the squared coefficients. Finally, the index of dissimilarity (*ID*) (Massey & Denton, 1988) (see Eq. (1)) is employed to measure housing tenure segregation, which was also reported by Li and Wu (2008):

$$ID = \sum_{i=1}^n \frac{t_i * abs(p_i - P)}{2 * T * P * (1 - P)} \quad (1)$$

where t_i and p_i are the total population and the minority population proportion within areal unit i , and T and P are the population size and minority population proportion of the whole city that is subdivided into n areal units. 'Abs' means calculation of an absolute value.

However, given the significant dissimilarity in segregation between the new development areas and inner city ones, *ID* fails to show any significance with variables other than housing tenure. As a result, the relative index of diversity H/H_{\max} is used to describe the unevenness and diversity of social groups in each social area:

$$H = - \sum_{i=1}^R S_i \ln S_i \quad (2)$$

where H is the Shannon–Wiener index (1949) of each cluster (social area), H_{\max} is the maximum value among all clusters, S_i is the

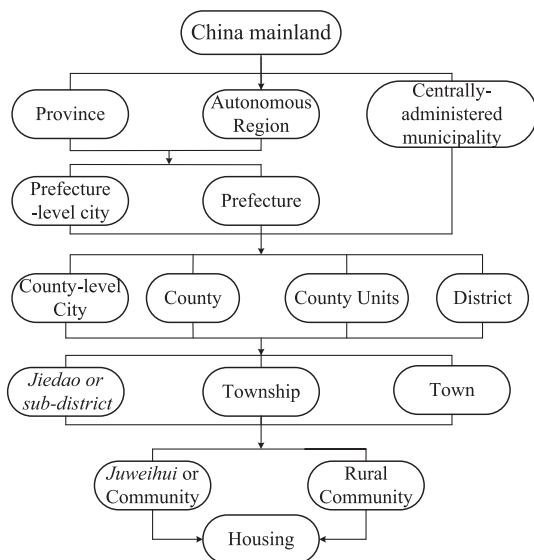


Fig. 1. A schematic diagram of China's fifth population census statistical unit. Source: China's population census survey in 2000.

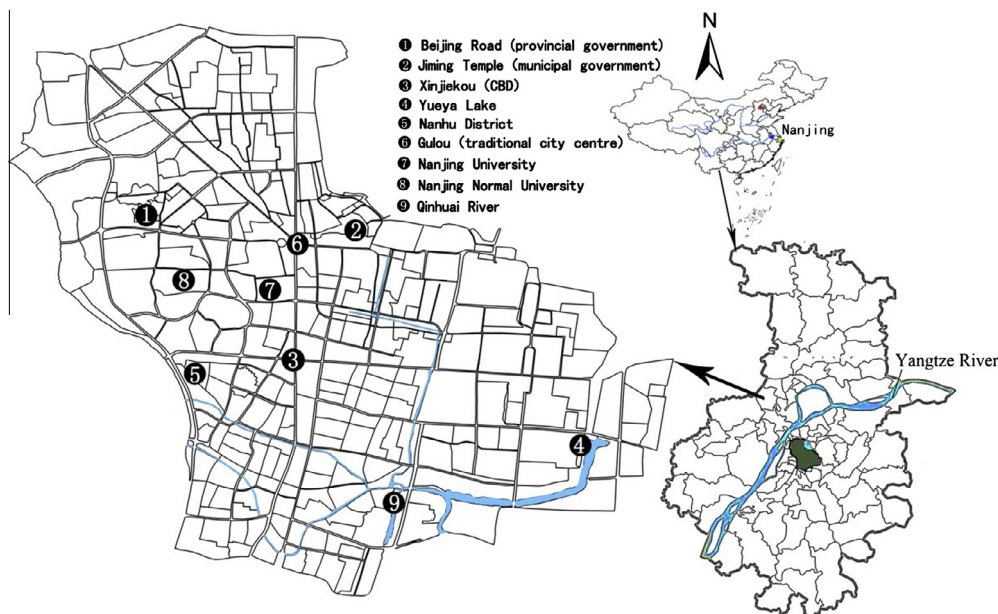


Fig. 2. Study area – inner city of Nanjing.

proportion of i th social group in the social area and R is the total number of social groups.

Results

Urban social groups

The PCA analysis with 36 variables yielded 8 components after 9 iterations when a Quartimax rotation method was selected (Table 1).

Among the eight components, components II, III, IV, V, and VIII have been confirmed to be interpretable for socio-spatial structure in the cities of Guangzhou and Nanjing by previous studies (Li et al., 2010; Song & Wu, 2010; Yeh et al., 1995) but at different geographical scales (*jiedao* or limited residential areas). For example, Component II, the housing component, is characterized by its high correlations with housing variables. A small part of the housing differentiated by this component is in older buildings, but much of the rest is in modern-style buildings with provision of indoor plumbing and hot water. The majority of the housing was purchased (i.e. privately owned) from former *danwei* or public institutions, which is quality housing but clearly not regarded as high-end housing. Component III identifies the intellectual class, including professionals and technical workers with high-level education, which has a negative correlation with employment in retailing and social services. Component IV reveals cadre housing, which describes the percentage of residents employed as governmental officials or managers

and being members of the Communist Party. This type of housing is often near governmental offices or stylized as gated communities with strict access control, and all with high market value and quality. Component IV accounts for 6.72% of the variation, showing the continuing influence of the ruling elites on political powers in the new market-based economy. Component V mainly differentiates government clerical workers (civil servants) living in high-rise buildings from other groups. Component VIII identifies low-level service workers, but is most distinguished from the other components by the availability of tap water in their residences.

The other three components—I, VI, and VII—can be distinguished according to the ways of how cities are portrayed and have been proved to be influential in previous studies (Li et al., 2010; Yeh et al., 1995). These three components address several interesting issues for further exploration. First, Component I, the primary component identifies communities with the following characteristics: a large number of small families (principal component loading is -0.810), high percentage of school-age children (0.834), a large proportion of female population (-0.716), and a high proportion of elderly population (0.616). This component is referred to as educationization (or *jiaoyufication*, *jiaoyu* means education in Chinese), which is indicative of a new form of gentrification around high-quality primary and secondary schools (Fig. 3).

Second, Component VI reveals a powerful professional-managerial class, who are quite young (-0.358), working mainly in the lucrative state sectors, such as finance, insurance, and real estate (0.380) and likely living in newer housing (0.869). Remarkably,

Table 1
Total variance explained in the social structure factor analysis of Nanjing in 2000.

Component	Extraction sums of squared loadings Eigenvalues	Rotation sums of squared loadings Percentage of variance (%)	Eigenvalues
I	6.343	17.618	6.343
II	5.676	15.767	5.676
III	3.298	9.160	3.298
IV	2.420	6.721	2.420
V	1.863	5.175	1.863
VI	1.705	4.736	1.705
VII	1.344	3.734	1.344
VIII	1.242	3.450	1.242

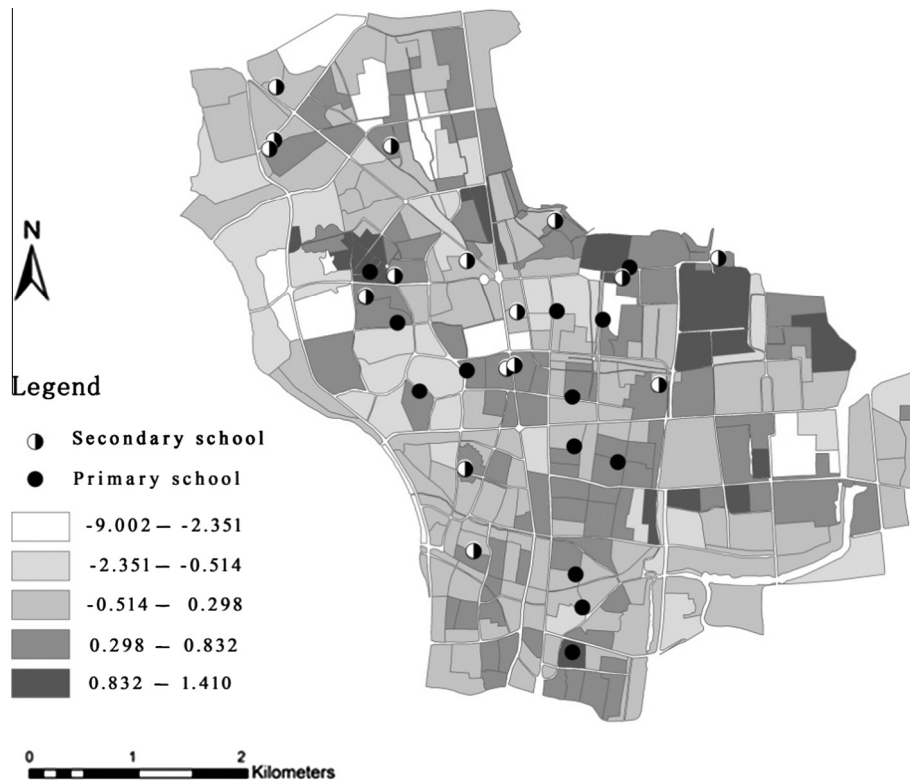


Fig. 3. The spatial distribution of *jiaoyufication* factor score and main schools.

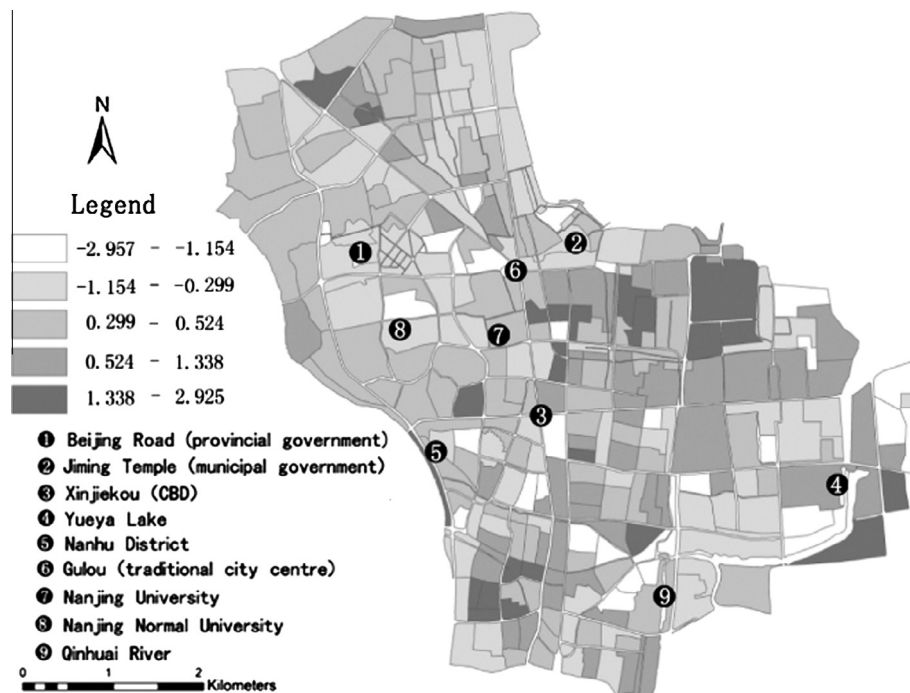


Fig. 4. The spatial distribution of financial and real estate factor scores.

the new and high-quality housing was purchased at a much lower price than its market value (0.153). The contributing reason is that this social group is able to receive housing welfare benefits as the “institutional bias” (Chen, 2012) favors this new elite class.

Members of this social group either pursue market-oriented high-profit careers (e.g., real estate tycoons are always listed in the Chinese *Forbes*) or are over-represented in the distribution of

monopolized social resources in public sectors, such as mines, land, electric power, and financial capital. This stratum benefits from highly-paid jobs in the free market and institutional welfare. Many members of this social group live in gated communities near Yueya Lake, one of the city’s earliest up-market commodity housing complexes, although some others are housed in the commercial center or near the provincial government offices in the old center (Fig. 4).

Third, Component VII presents a complex mix of variables and it explains less than four percent of the variation, but we believe it is likely an indicator of a new and growing force occurring in the process of Chinese urbanization. This component can distinguish the better quality purchased housing and higher-end rental housing buildings from others. However, this component has weak correlations with most occupational variables or education.

The census data at sub-district level shows that a high proportion of this type of housing is utilized as stores, restaurants, and cafés, etc. Hence, it can be inferred that this component may reveal those communities populated in part by an emerging entrepreneurial class, which is of higher status than shop and small business owners. In 2000, this small group represented an emerging capitalist class in Nanjing distinct from the dominant capitalist class associated with the cadre. While such a spontaneously occurring entrepreneurial class is not a new phenomenon in Chinese cities, this appears to be the first time it can be linked to particular community areas. Furthermore, at the community level, such housing category is negatively correlated with the numbers of male (-0.05) and front-line workers in commerce and services sectors (-0.23), while positively correlated with social services (0.323). Members of this self-employed group typically purchase former public housing (0.207), commercial housing (0.189), and affordable housing (0.109), but they do not rent commercial housing. The dispersed pattern shown by the scores of this component throughout the study area indicates that a large number of civil servants, teachers, and workers in the SOEs (State Own Enterprise) resigned from their jobs and started their own business (“*xiaohai jinshang*” in Chinese) in the latter half of the 1990s. It can be clearly seen in Fig. 5 that this social group is located close to commercial centers and within high-density residential areas (see Table 2).

In summary, the results above demonstrate that Chinese inner cities experienced massive change in their socio-spatial structure at the turn of the 21st century. The results have also confirmed that the current urban social space originates from the combined forces of free market and institutional power.

Urban socio-spatial clusters

After running a cluster analysis, seven clusters were created to best depict the socio-spatial characteristics of the study area (Fig. 6).

Cluster I, accounting for 17.24% of the total 244 community areas, is referred to as a high-status cluster since the residents in this cluster have the most institutional power, wealth, and authority in general. This cluster has a significant proportion of public civil servants (Component V), whose value is 0.074, being higher than those of intellectual (Component III), cadre (Component IV), and professional managerial (Component VI) (0.073, 0.063, and 0.062 respectively; see Table 3).

The relative diversity index (according to Eq. (2)) of Cluster I is 1.0, the highest among all clusters (see Table 4) and this indicates the most even distribution across the study area, such as the areas in the south of *Xinjiekou* (CBD), and also provincial and municipal government areas. The new development areas in the south resulted from the urban redevelopment projects taking place from the early 1990s onwards, such as a built-environment beautification campaign in the mid-1990s, and a wave of new-build gentrification and underclass replacement near the CBD in the late 1990s.

Clusters II and III both encircle the “high-status” areas and show a higher global diversity (0.410 and 0.484 respectively) across the study area though they have different components. Cluster II, spatially concentrated in the west and around *Xinjiekou*, is referred as the “self-employers and intellectuals cluster”. Cluster III comprises public civil servants, cadre, and intellectuals, more closely connected to bureaucratic power and more stable in their lives. These two clusters account for 47.12% of the total 244 communities, and constitute the majority of the white-collar working class in this city. The stability and diversity shown above indicate that there has been successful social integration in daily life and geographical interaction between public civil servants and intellectuals since the Capital Plan of the 1930s.

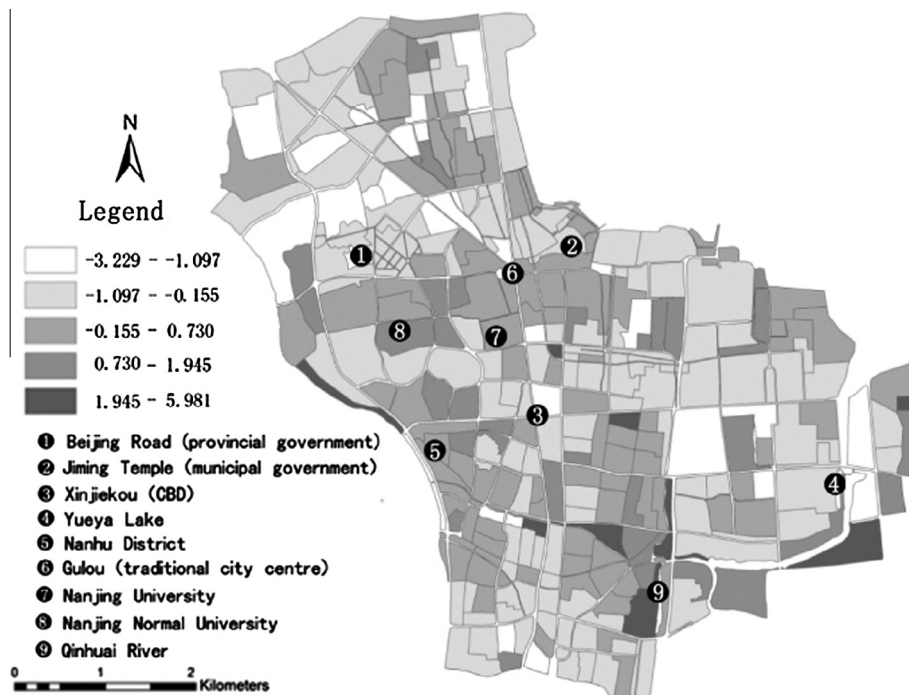


Fig. 5. The spatial distribution of self-employed factor scores.

Table 2
Rotated component matrix.

	I	II	III	IV	V	VI	VII	VIII
Percent male	-.716	.082	.055	.081	-.125	-.011	-.050	-.066
Percent <15 years old	.834	-.018	.208	-.121	.214	.251	.117	-.081
Percent 15–29 years old	-.949	-.054	-.005	.324	.016	-.104	-.187	.189
Percent 30–59 years old	.865	.043	.082	-.420	.015	.267	.232	-.215
Percent 60 years old or above	.616	.087	-.270	-.073	-.209	-.358	.035	-.094
Mean family size	-.810	-.071	-.014	.271	-.052	-.175	-.506	.106
Mean years of education	-.638	.267	.246	.757	.346	-.008	-.047	-.003
Percent manufacturing and construction	.185	-.047	-.287	-.170	-.770	-.050	-.043	-.032
Percent transport and communications	.165	.094	-.166	-.232	.020	.276	-.129	-.269
Percent wholesale, retailing, and catering	.205	-.298	.054	-.773	-.117	-.090	.000	.272
Percent finance, insurance, and real estate	.216	.117	.276	.143	.389	.380	.182	-.087
Percent social services	.120	-.083	.180	-.500	.244	.066	.323	-.195
Percent state, party, and community organizations	.170	.201	.048	.208	.712	.142	-.035	-.124
Percent other industries	-.044	-.009	-.078	.393	.214	-.063	.147	-.057
Percent CCP, government, institution, managers/cadres, and enterprise managers	.142	.292	.694	.259	.516	.350	.173	-.209
Percent professional and technical workers	-.282	.285	.238	.848	.324	.046	.098	-.061
Percent clerical and related workers	.130	.225	.005	.067	.662	.303	.161	-.343
Percent frontline workers in commerce and services	.010	-.430	-.309	-.798	-.358	-.324	-.230	.335
Percent other frontline workers	.018	.077	.005	-.025	-.031	-.082	.047	-.205
Mean building floor area per capita (sq m)	.530	.318	.704	.141	.393	.479	.231	-.221
Percent with own kitchen	.152	.830	.280	.334	.437	.481	.459	-.201
Percent with gas as fuel	.578	.303	.090	.010	.202	.283	.740	-.191
Percent with tap water	.077	.052	-.002	.019	-.111	-.034	.657	.003
Percent 7 stories or above	-.059	-.018	.084	.347	.443	-.206	.064	.054
Percent built before 1950	.120	-.766	-.221	-.207	-.213	-.193	-.107	.000
Percent built 1950–1979	-.093	-.402	-.246	.173	-.386	-.537	-.489	.115
Percent built 1980–1989	-.037	.446	-.185	-.090	.137	-.557	.172	-.123
Percent built 1990–2000	.023	.209	.403	.088	.194	.869	.167	.045
Percent self-built	.049	-.669	-.188	-.423	-.405	-.454	-.289	.308
Percent purchased commodity housing	-.021	.034	.817	-.037	.216	.403	.189	-.149
Percent purchased economic and comfortable housing	.032	.050	.132	-.143	.012	.157	.109	.627
Percent purchased former public housing	.068	.870	-.090	.374	.127	-.013	.207	-.307
Percent rented public housing	.051	-.712	-.370	-.116	-.027	.055	.000	-.005
Percent rented commodity housing	.042	-.211	.044	-.425	-.267	-.193	-.110	.670
Mean purchase price (RMB 10,000 Yuan)	-.017	.373	.747	.006	.123	.153	.153	.233
Mean monthly rent (RMB Yuan)	.004	.110	.839	.088	.062	.210	.070	.170

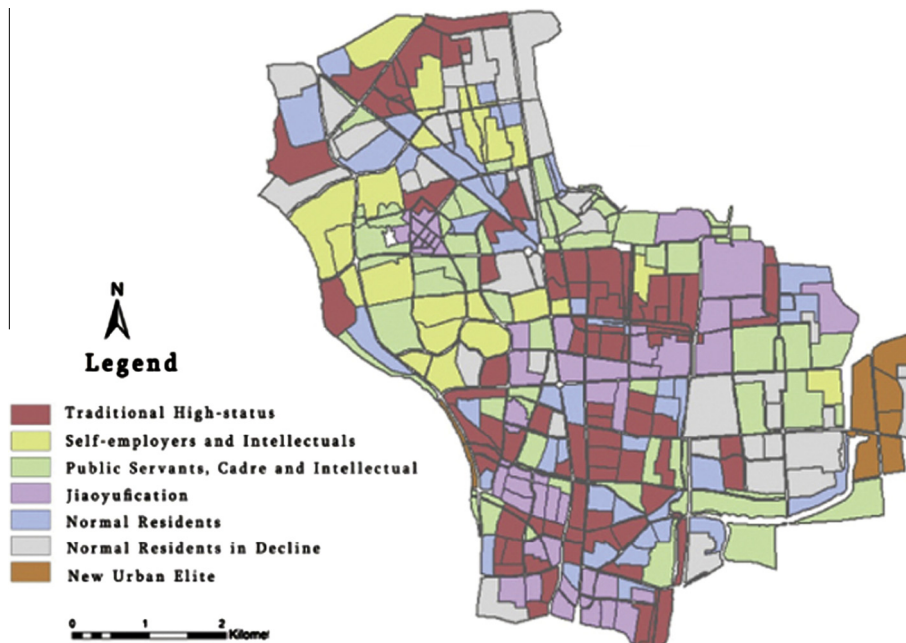


Fig. 6. The social areas of the inner city of Nanjing based on cluster analysis.

Cluster IV, accounting for 14.75% of all communities, is dominated by the components of the *jiaoyufication* factor and the professional-managerial class factor. Its relative diversity index is 0.294. This high-status cluster is referred as the “*jiaoyufication*”

cluster because of its dominant component, *jiaoyufication*. Its areas are very close to the best schools in the two districts with the highest value of *jiaoyufication* factor: *Gulou* and *Xuanwu* Districts (Fig. 2).

Table 3
Identification of clusters.

Cluster Area	Number of communities	I	II	III	IV	V	VI	VII	VIII
Traditional High-status	43	0.038	0.057	0.073	0.063	0.074	0.062	0.035	0.042
Self-employers and intellectuals	52	0.016	0.051	0.011	0.047	0.025	0.044	0.067	0.04
Public servants, cadre and intellectual	63	0.025	0.057	0.044	0.049	0.077	0.034	0.022	0.036
Jiaoyufication	18	0.37	0.293	0.093	0.207	0.174	0.335	0.298	0.143
Normal residents	36	0.046	0.031	0.025	0.034	0.042	0.054	0.085	0.06
Normal residents in decline	22	0.241	0.187	0.274	0.198	0.036	0.188	0.134	0.28
New urban elite	10	0.177	0.268	0.212	0.248	0.388	0.395	0.271	0.193

Table 4
The index of diversity.

Cluster	H	H/H_{\max}
Traditional high-status	0.529	1.000
Self-employers and intellectuals	0.256	0.484
Public servants, cadre and intellectual	0.217	0.410
Jiaoyufication	0.156	0.294
Normal residents	0.234	0.442
Normal residents in decline	0.163	0.308
New urban elite	0.019	0.035

Cluster V (accounting for 14.75%) is inhabited by mixed residents, although the communities to the south of *Xuanwu Lake* have a relatively high percentage of the professional-managerial class, and some provincial-government and military cadre villas are spread along the edge of the high-status cluster near the provincial government in the northwest area of *Gulou*.

In contrast with Cluster V in the north, Cluster VI is located in the densely populated center south of *Xinjiekou*. This cluster has a lower value of diversity than Cluster V: 0.308 compared to 0.442. The settlement of the invading intellectual group as new-build gentrifiers into some gated communities around *Xinjiekou* has crowded out lower-class social groups.

Cluster VII, or the newly formed economic and political “urban elite” cluster, largely comprises middle-class cadres and managers of SOEs, mixed with a small number of successful self-employers, who usually live in good quality housing in gated communities around *Yueya Lake*. The relative diversity index of this cluster is lowest, being 0.035; but the ID value of the cadres and managers of the SOEs, 0.650, is the highest. The social component of this cluster is divided into cadres and managers, and non-cadres-managers and the ID value calculated by this bisection method is listed in Table 5. It is evident that this socio-spatial group has accumulated great wealth through institutional power, the free market or both, and they are the direct beneficiaries of Chinese neoliberalisation practices. As this cluster has the lowest value of diversity in the inner city, these communities have formed “upper-middle-class” enclaves that offer exclusive rights to communities that increasingly resemble those found in the Western context.

Discussion

New urban forms

The socio-spatial structure of the inner city in Nanjing revealed above demonstrates a concentric pattern, with the lower-profiled social areas encircling the areas of the provincial-government cadre housing which in turn surrounds the high-status cluster in the city center. This exhibits a clear path-dependence pattern originating from the Capital Master Plan in 1929. However, the appearance of new middle-class areas in 1997 on the edge of the inner city has dramatically changed this pattern. The occurrence of the middle-class enclaves not only broke down the mono-centric pattern with a twin-center structure, but also promoted the growth of

new higher-status social groups in urban society. Whereas other internationalized cities such as Beijing and Shanghai had experienced this change in the early 1990s, many mega cities in China such as Nanjing went through the process at the turn of the new century.

These patterns suggest that the evolution and models of socio-spatial segregation in Chinese cities follow the Chicago School's logic, although Chinese cities may differ from each other with regard to urban life and respective development paths. First, both the clusters from the higher social clusters and the very lowest social areas display a tendency to become segregated rather dispersed. For example, the elite cluster along *Yueya Lake* has the highest level of unevenness ($ID = 0.651$ in Table 5) but the lowest level of diversity (H/H_{\max} is 0.035 in Table 4). Second, the clusters between the top and bottom of the continuum are more diverse and less segregated. Finally, the newly built residential areas show normally more uneven distribution and less diverse pattern than those old communities, and vice versa (Tables 4 and 5), which suggests that market forces increase segregation in the economy and space.

A dual path of socio-spatial differentiation

There are two paths of socio-spatial differentiation and transition (Harvey, 1990): (1) the destructive creation of neighborhoods and (2) the creative destruction of neighborhoods. Both paths have been observed in this case study of Nanjing. First, the underclass neighborhoods in the city center, such as the *Gulou* district near Nanjing University campus and the *Nanhu* district near the south Ming city wall, were all demolished and the new-build gentrifiers moved to reside here through the housing market system. Throughout the city, an increasing number of old communities disappeared after the mid-1990s. This process was initiated by small-scale improvements or maintenance, followed by demolition of the entire community, in order to make way for new urban construction projects. Not only were those buildings pulled down and their residents relocated, but also the names of streets were changed and the entire landscape removed. This redevelopment process, often referred to as new-build gentrification (Davidson & Lees, 2005), directly or indirectly threatens the diversity of neighborhoods and increases the level of segregation at the micro-scale by implanting gated communities in the traditional urban fabric.

Second, in contrast to the demolished neighborhoods, other areas have experienced reconstruction and spatial transformation through small-scale building maintenance and an influx of new residents. This is the so-called process of “creative destruction,” during which the built-environment and the demographic structure of communities is updated over time, as often seen in the process of traditional gentrification. For example, the facades of buildings along the commercial walking street near *Xinjiekou* have been either refurbished or rebuilt. The refurbished buildings around the campus of Nanjing University were rented as cafés and bars to cater to an aspiring group of consumers, apprentice gentrifiers in an internationalized neighborhood under the impact of studentification (Smith & Holt, 2007).

Table 5

The index of dissimilarity of profession in social clusters.

Cluster	Cadre and manager of SOE	Professional and technical workers	Clerical and related workers	Frontline workers in commerce and services	Frontline workers in agriculture and fishing	Frontline workers in transportation and manufacture	Other frontline workers
Traditional high-status	0.372	0.290	0.209	0.290	0.434	0.115	0.102
Self-employers and intellectuals	0.179	0.117	0.118	0.095	0.702	0.092	0.916
Public servants, cadre and intellectual	0.186	0.129	0.118	0.122	0.694	0.139	0.972
Jiaoyufication	0.148	0.165	0.145	0.123	0.816	0.168	0.151
Normal residents	0.131	0.104	0.125	0.134	0.6	0.127	0.127
Normal residents in decline	0.194	0.144	0.142	0.106	0.875	0.073	0.063
New urban elite	0.650	0.418	0.274	0.145	0.195	0.611	0.242

A new form of gentrification: Jiaoyufication

Compared to existing case studies of Chinese cities this analysis is the first to apply principal component analysis for socio-spatial structure analysis at the community level. An interesting and new phenomenon of education-based residential segregation, *jiaoyufication*, has been detected and confirmed from a geographical perspective in a Chinese city. It reveals the long-term impact of market-led educational reform upon the pattern and socio-spatial structure of the inner city of Nanjing. In general, the social areas of *jiaoyufication* are characterized by the following patterns different from those of other known social areas:

(1) *jiaoyufication* communities are highly mobile and unevenly situated around the housing compounds of several 'powerful' institutions, such as the educational bureau, and municipal or provincial governments, where the best schools are often located. Principally, only those children with local *hukou* and in the catchment area or particularly with family members who are employees of these organizations (or work units) are allowed to enroll in these attractive schools. Those who do not meet these requirements have to pay a high contribution fee in order to gain a place for their children. This explains why the communities around the high-quality schools are full of temporary residents who only live in that area for the period of their children's schooling; (2) The households in these communities are usually very small, comprising of school children and their mothers or grandmothers; (3) community members have strong economic capacities and well-developed social networks. In some sense, *jiaoyufication* provides these young residents with an environment where they can develop socio-relational networks which assist them in the future; (4) the old buildings show that gentrifiers have little interest in refurbishing their houses, which differs from their Western counterparts. In summary, the unevenly distributed educational resources, in conjunction with the housing market and traditional culture, have created massive impacts on the internal structure of urban areas and shaped daily urban life. In traditional Chinese culture people have a particular interest in investing in their children's (or even grandchildren's) education. Such investment continues from nursery to higher education in both urban and rural areas. The increasing number of overseas Chinese students studying in Western universities is a good example of this trend.

Hybrid dynamic mechanism of Chinese urban socio-spatial differentiation

Previous studies on China's urban socio-spatial structure, for example, from the political economy perspectives of Shanghai's development zones (He & Wu, 2005), Guangzhou's (Yeh et al., 1995), and Beijing's regeneration (Hu and Kaplan, 2001; Leaf, 1995), as well as studies of urban poverty in Nanjing (Chen, Gu, & Wu, 2006), are characterized by a limited sample size or number of case study communities, based on which the social space and dynamic mechanism of Chinese urban socio-spatial transformation

was deduced to some degree. The case study presented in this paper using aggregated data from a full-size population sample (census data at community level) and covering a large area of the city is expected to confirm or consolidate previous hypotheses and statements.

Our analysis has revealed the changes in the socio-spatial patterns of the inner-city. As with the socio-spatial pattern of Nanjing in the 1930s, the center area around the provincial government offices remain occupied by government officials and the more affluent class (Wu, 2001). However, another new upper-class concentrated area developed just outside of east Ming city wall in the late 1990s (Fig. 5). This indicates that the typical concentric pattern of urban social space of the inner city of Nanjing had been transformed into a multi-center pattern by 2000.

Nevertheless, this transformation, which began in 1978, is characterized by a gradual and hybrid socio-spatial process rather than by a sharp and simplified change. Similar to other mega cities across China, Nanjing experienced a large-scale growth-led urban regeneration during the late 1990s, which, however, failed to significantly change the pattern of residential segregation or spatial differentiation of the inner city as a whole. Furthermore, this process was not only determined by traditional market forces, housing preference and the demographic structure, but was also affected by institutional forces. As with Li and Siu (2001), echoing Van Kempen and Özüekren's (1998) hypothesis of a hybrid dynamic mechanism in urban segregation, this study suggests that the occurrence of *Jiaoyufication*, for instance, was stimulated by Chinese institutional factors, such as *danwei*, and the institutional arrangement of educational resources, in conjunction with the constraints on households and individuals.

Conclusion

In this paper, principal component analysis, cluster analysis, and segregation indices have been employed to analyze the socio-spatial differentiation and residential segregation patterns of a historic Chinese city based on a rarely used community-level census data set.

First, methodologically, the socio-economic factor analysis (as a widely used method for classifying social areas) offers the advantage of interpreting the socio-spatial patterns and the political and socio-economic processes behind them. Given that there are many meaningful zeroes in census data rendering it a non-positive definite matrix, other dimension reduction methods such as Canonical Variate Analysis cannot be used efficiently and effectively.

Second, the statistical analysis at the community level has helped to identify several emerging socio-spatial groups and clusters, such as the gentrifiers of *jiaoyufication* and the self-employed and middle-class clusters, which were not reported in previous studies due to data limitations. Furthermore, it has also been found that indices of diversity such as the Shannon index or the relative Shannon index are more appropriate for revealing the evenness of

urban life in the Chinese inner-city than the *ID* index. The latter fails to reveal multi-factor segregation at the scale of the social areas.

Third, when applying the Shannon index and the *ID* index to measure socio-spatial differentiation and residential segregation at the community level, both index values show a contrasting difference for high-status and low-status social areas: low in the Shannon index but high in the *ID* index. Moreover, the newly built areas are inclined to demonstrate a higher level of unevenness and a lower level of diversity than those old areas, and vice versa.

In summary, the empirical study enables us to suggest the following:

- (1) Although the impact of institutional factors (such as *danwei*) on urban social space is waning, there is a strong path-dependence in which traditional institutional forces continue to exert their influence on housing distribution and its socio-spatial pattern during the introduction of the market system (Chen, 2012).
- (2) This path-dependence of institutional effects in combination with market forces is producing new social groups and segregated communities in urban China, who are the most direct beneficiaries of the country's gradualist approach to reform from within the system. This hypothesis needs further analysis and confirmation using the latest 2010 census data when it is available.
- (3) Although the *jiaoyufication* cluster in the urban core and the new urban elite cluster on the edge that are detected at community level may be specific to local and regionalized circumstances, both follow the socio-spatial patterns proposed by the Chicago schools (Park et al., 1967). This paradox implies that the regionalized (in our case, non-Western) impact on Chinese urban social space is similar to that of Western (or global) cities. It is not intended to over-generalize our case study, but it is possible to state that the urban social space in some non-western cities is a hybrid outcome of endogenous institutional inertia and the impact of market-led practices. This is a new contribution of this study to the understanding of socio-spatial structure of Chinese cities using the census data at community level, compared with those using data at different scales (Li et al., 2010) or with varied degree of spatial accuracy (Li & Wu, 2008). More case studies, particularly using the latest 2010 census data at the same level when it becomes officially available, are needed to further confirm these new findings.
- (4) In the model proposed by Madrazo and Van Kempen for Chinese cities (2012) the impacts of forces other than policy on urban development processes have not been examined in the case of Chinese cities. Similarly, other factor such as legislative zoning or laws on residential racial segregation (which was examined in the case of Hong Kong (Lai & Kwong, 2012)) should be explored in Mainland China as well.

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References

- Chen, G. (2012). Structural evaluation of institutional bias in China's urban housing: The case of Guangzhou. *Environment and Planning – Part A*, 44(12), 2867–2882.
- Chen, G., Gu, C., & Wu, F. (2006). Urban poverty in the transitional economy: A case of Nanjing, China. *Habitat International*, 30(1), 1–26.
- Cheng, J., Turkstra, J., Peng, M., Du, N., & Ho, P. (2006). Urban land administration and planning in China: Opportunities and constraints of spatial data models. *Land Use Policy*, 23(4), 604–616.
- Davidson, M., & Lees, L. (2005). New-build 'gentrification' and London's riverside renaissance. *Environment and Planning – Part A*, 37(7), 1165–1190.
- Friedmann, J. (2010). Place and place-making in cities: A global perspective. *Planning Theory & Practice*, 11(2), 149–165.
- Gale, R. (2013). Religious residential segregation and internal migration: The British Muslim case. *Environment and Planning – Part A*, 45, 872–891.
- Gu, C., Wang, F., & Liu, G. (2005). The structure of social space in Beijing in 1998: A socialist city in transition. *Urban Geography*, 26(2), 167–192.
- Harvey, D. (1990). *The condition of postmodernity: An enquiry into origins of culture change*. New York: Blackwell Publishers Inc.
- He, S., & Wu, F. (2005). Property-led redevelopment in post-reform China: A Case study of XintianDi redevelopment project in Shanghai. *Journal of Urban Affairs*, 27(1), 1–23.
- Hu, X., & Kaplan, D. H. (2001). The emergence of affluence in Beijing: Residential social stratification in China's capital city. *Urban Geography*, 22(1), 54–77.
- Iceland, J., & Sharp, G. (2013). White residential segregation in U.S. metropolitan areas: Conceptual issues, patterns, and trends from the U.S. census, 1980 to 2010. *Population Research and Policy Review*, 32(5), 663–686.
- Johnston, R., Michael, P., & James, F. (2007). The geography of ethnic residential segregation: A comparative study of five countries. *Annals of the Association of American Geographers*, 97(4), 713–738.
- Kazepov, Y. (2005). *Cities of Europe: Changing contexts local arrangements and the challenge to social cohesion*. Oxford: Blackwell.
- Lai, L. W. C., & Kwong, V. W. C. (2012). Racial segregation by legislative zoning and company law: An empirical Hong Kong study. *Environment and Planning – Part B*, 39(3), 416–438.
- Leaf, M. (1995). Inner city redevelopment in China: Implications for the city of Beijing. *Cities*, 12(3), 149–162.
- Li, S., Hou, Q., Chen, S., & Zhou, C. (2010). Work, home, and market: The social transformation of housing space in Guangzhou, China. *Urban Geography*, 31(4), 434–452.
- Li, S. M., & Siu, Y. M. (2001). Residential mobility and urban restructuring under market transition: A study of Guangzhou, China. *The Professional Geographer*, 53(2), 219–229.
- Li, Z., & Wu, F. (2008). Tenure-based residential segregation in post-reform Chinese cities: A case study of Shanghai. *Transactions of the Institute of British Geographers*, 33(3), 404–419.
- Liu, Y., Dijst, M., & Geertman, S. (2014). Residential segregation and well-being inequality between local and migrant elderly in Shanghai. *Habitat International*, 42, 175–185.
- Logan, J. R. (2013). The persistence of segregation in the 21st century metropolis. *City Community*, 12(2), 160–168.
- Madrazo, B., & van Kempen, R. (2012). Explaining divided cities in China. *Geoforum*, 43(1), 158–168.
- Massey, D. S. (2012). Reflections on the dimensions of segregation. *City Community*, 12(2), 72–93.
- Massey, D. S., & Denton, N. (1988). The dimensions of residential segregation. *Social Forces*, 67(2), 281–315.
- Park, R. E., Burgess, E. W., & McKenzie, R. D. (1967). *The city*. Chicago: University of Chicago Press.
- Peach, C. (2006). Islam, ethnicity and South Asian Religions in the London 2001 census. *Transactions of the Institute of British Geographers*, 31(3), 353–370.
- Shannon, C. E., & Weaver, W. (1949). *The mathematical theory of communication*. Urbana: Univ. Illinois Press.
- Shen, J. (2002). A study of the temporary population in Chinese cities. *Habitat International*, 26(3), 363–377.
- Shevky, E., & Bell, W. (1955). *Social area analysis*. California: Stanford Univ. Press.
- Simone, A. (2004). *For the city yet to come: Changing African life in four cities*. Durham and London: Duke University Press.
- Smith, D. P., & Holt, L. (2007). Studentification and apprentice' gentrifiers within Britain's provincial towns and cities: Extending the meaning of gentrification. *Environment and Planning – Part A*, 39(1), 142–161.
- Song, W., & Wu, Q. (2010). Gentrification and residential differentiation in Nanjing, China. *Chinese Geographical Science*, 20(6), 568–576.
- Tian, G., Wu, J., & Yang, Z. (2010). Spatial pattern of urban functions in the Beijing metropolitan region. *Habitat International*, 34(2), 249–255.
- Van Kempen, R., & şule Özüekren, A. (1998). Ethnic segregation in cities: new forms and explanations in a dynamic world. *Urban studies*, 35(10), 1631–1656.
- Wang, Y. P. (2003). *Progress and problems of urban housing reform. Social policy reform in China: Views from home and abroad*. Hants, UK: Ashgate Publishing Co.

- Wu, F. (2002). Sociospatial differentiation in urban China: Evidence from Shanghai's real estate markets. *Environment and Planning – Part A*, 34(9), 1591–1616.
- Wu, F., & He, S. (2005). Changes in traditional urban areas and impacts of urban redevelopment: A case study of three neighborhoods in Nanjing, China. *Tijdschrift Voor Economische en Sociale Geografie*, 96(1), 75–95.
- Wu, F., & Webster, C. J. (Eds.). (2010). *Marginalization in urban China: Comparative perspectives*. UK: Palgrave Macmillan.
- Wu, Q. (2001). *The differentiation of residential space in Chinese metropolitan areas*. Beijing: Science Press House (in Chinese).
- Yeh, A. G. O., Xu, X., & Hu, H. (1995). The social space of Guangzhou city, China. *Urban Geography*, 16(7), 595–621.
- Zhao, P. (2013). The impact of urban sprawl on social segregation in Beijing and a limited role for spatial planning. *Tijdschrift Voor Economische en Sociale Geografie*, 104(5), 571–587.